Part III
Protecting Surface Water

Chapter 6
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Contents

Contents (cont.)

Protecting Surface Water

This chapter will help you:

- *Protect surface waters by limiting the discharge of pollutants into the waters of the United States.*
- *Guard against inappropriate discharges of pollutants associated with process wastewaters and storm water to ensure the safety of the nation's surface waters.*
- *Reduce storm-water discharges by complying with applicable regulations, implementing available storm-water controls, and identifying best management practices (BMPs) to control storm water.*

Over 70 percent of the Earth's surface is water. Of all the Earth's water, 97 percent is found in the oceans and seas, while 3 percent is fresh water. This fresh water is found in glaciers, lakes, ground water, wetlands, and rivers. Because water is such a valuable commodity, the protection of our surface waters should be everyone's goal. Pollutants[1] associated with waste management units and storm-water discharges must be controlled.

> This chapter will help you address the following questions:
>
> - What surface-water protection programs are applicable to my waste management unit?
> - What are the objectives of run-on and runoff control systems?
> - What should be considered in designing surface-water protection systems?
> - What BMPs should be implemented to protect surface waters from pollutants associated with waste management units?
> - What are some of the engineering and physical mechanisms available to control storm water?

This chapter summarizes how EPA and states determine the quality of surface waters and subsequently describes the existing surface-water protection programs for ensuring the health and integrity of waterbodies. The fate and transport of pollutants in the surface-water environment is also discussed. Finally, various methods that are used to control pollutant discharges to surface waters are described.

I. Determining the Quality and Health of Surface Waters

The protection of aquatic resources is governed by the Clean Water Act (CWA). The objective of the CWA is to "restore and maintain the chemical, physical, and biological

[1] To be consistent with the terminology used in the Clean Water Act, the term pollutant is used in this chapter in place of the term constituent. In this chapter, pollutant means an effluent or condition introduced to surface waters that results in degradation. Water pollutants include human and animal wastes, nutrients, soil and sediments, toxics, sewage, garbage, chemical wastes, and heat.

What is water quality?

Water quality reflects the composition of water as affected by natural causes and human activities, expressed in terms of measurable quantities and related to intended water use. Water quality is determined by comparing physical, chemical, biological, microbiological, and radiological quantities and parameters to a set of standards and criteria. Water quality is perceived differently by different people. For example, a public health official might be concerned with the bacterial and viral safety of water used for drinking and bathing, while fishermen might be concerned that the quality of water be sufficient to provide the best habitat for fish. For each intended use and water quality benefit, different parameters can be used to express water quality.

integrity of the nation's waters" (Section 101(a)). Section 304(a) of the CWA authorizes EPA to publish recommended water quality criteria that provide guidance for states to use in adopting water quality standards under Section 303(c). Section 303 of the CWA also establishes the Total Maximum Daily Load (TMDL) Program which requires EPA and the states to identify waters not meeting water quality standards and to establish TMDLs for those waters.

A. Water Quality Criteria

Under authority of Section 304 of the CWA, EPA publishes water quality "criteria" that reflect available scientific information on the maximum acceptable concentration levels of specific chemicals in water that will protect aquatic life, human health, and drinking water. EPA has also established nutrient criteria (e.g., phosphorus and nitrogen) and biological criteria (i.e., biointegrity values). These criteria are used by the states for developing enforceable water quality standards and identifying problem areas.

Water quality criteria are developed from toxicity studies conducted on different organisms and from studies of the effects of toxic compounds on humans. Federal water quality criteria specify the maximum exposure concentrations that will provide protection of aquatic life and human health. Generally, however, the water quality criteria describe the quality of water that will support a particular use of the water body. For the protection of aquatic life a two-value criterion has been established to account for acute and chronic toxicity of pollutants. The human health criterion specifies the risk incurred with exposure to the toxic compounds at a specified concentration. The human health criterion is associated with the increased risk of contracting a debilitating disease, such as cancer.

B. Water Quality Standards

Water quality standards are laws or regulations that states (and authorized tribes) adopt to enhance and maintain the quality of water and protect public health. States have the primary responsibility for developing and implementing these standards. Water quality standards consist of three elements: 1) the "designated beneficial use" or "uses" of a waterbody or segment of a waterbody, 2) the water quality "criteria" necessary to protect the uses of that particular waterbody, and 3) an antidegradation policy. "Designated use" is a term that is specified in water quality standards for a body of water or a segment of a body of water (e.g., a particular branch of a river). Typical uses include public water supply, propagation of fish and wildlife, and recreational, agricultural, industrial, and navigational purposes. Each state develops its own use classification system based on the generic

U.S. EPA Selected Water Quality Criteria in Micrograms per Liter

	Aquatic Life Freshwater		Marine		Human Health 10^{-6} Risk	
Chemical	**Acute**	**Chronic**	**Acute**	**Chronic**	**Water and Fish Ingestion**	**Fish Ingestion Only**
Benzene	5300	—	5100	700	0.66	40
Cadmium	—	—	43	9.3	10	—
DDT	1.1	0.001	0.13	0.001	0.000024	0.000024
PCBs	2	0.014	10	0.03	0.000079	0.000079

uses cited in the CWA. The states may differentiate and subcategorize the types of uses that are to be protected, such as cold-water or warm-water fisheries, or specific species that are to be protected (e.g., trout, salmon, bass). States may also designate special uses to protect sensitive or valuable aquatic life or habitat. In addition, the water quality criteria adopted into a state water quality standard may or may not be the same number published by EPA under section 304. States have the discretion to adjust the EPA's criteria to reflect local environmental conditions and human exposure patterns.

The CWA requires that the states review their standards at least once every three years and submit the results to EPA for review. EPA is required to either approve or disapprove the standards, depending on whether they meet the requirements of the CWA. When EPA disapproves a standard, and the state does not revise the standard to meet EPA's objection, the CWA requires the Agency to propose substitute federal standards.

C. Total Maximum Daily Load (TMDL) Program

Lasting solutions to water quality problems and pollution control can be best achieved by looking at the fate of all pollutants in a watershed. The CWA requires EPA to administer the total maximum daily load (TMDL) program, under which the states establish the allowable pollutant loadings for impaired waterbodies (i.e., waterbodies not meeting state water quality standards) based on their "waste assimilative capacity." EPA must approve or disapprove TMDLs established by the states. If EPA disapproves a state TMDL, EPA must establish a federal TMDL.

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the state has designated. The calculation must also account for seasonal variation in water quality.

The quantity of pollutants that can be discharged into a surface-water body without use impairment (also taking into account natural inputs such as erosion) is known as the "assimilative capacity." The assimilative capacity is the range of concentrations of a substance or a mixture of substances that will not impair attainment of water quality standards. Typically, the assimilative capacity of surface-water bodies might be higher for biodegradable organic matter, but it can be very low for some toxic chemicals that accumulative in the tissues of aquatic organisms and become injurious to animals and people using them as food.

What is a watershed?

Watersheds are areas of land that drain to surface-waterbodies. A watershed generally includes lakes, rivers, estuaries, wetlands, streams, and the surrounding landscape. Ground-water recharge areas are also considered part of a watershed. Because watersheds are defined by natural hydrology, they represent the most logical basis for managing surface-water resources. Managing the watershed as a whole allows state and local authorities to gain a more complete understanding of overall conditions in an area and the cumulative stressors which affect the surface-water body. Information on EPA's strategy to protect and restore water quality and aquatic ecosystems at the watershed level can be found at **<www.epa.gov/owow/watershed/index2.html>**

II. Surface-Water Protection Programs Applicable to Waste Management Units

To ensure that a state's water quality standards and TMDLs are being met, discharges of pollutants are regulated through the National Pollutant Discharge Elimination System (NPDES) Permit Program and the National Pretreatment Program. These permitting programs are implemented and enforced at the state or local level.

A. National Pollutant Discharge Elimination System (NPDES) Permit Program

The CWA requires most "point sources" (i.e., entities that discharge pollutants of any kind into waters of the United States) to have a permit establishing pollution limits, and specifying monitoring and reporting requirements. This permitting process is known as the National Pollutant Discharge Elimination System (NPDES). Permits are issued for three types of wastes that are collected in sewers and treated at municipal wastewater treatment plants or that discharge directly into receiving waters: process wastewater, nonprocess wastewater, and storm water. Most discharges of municipal and industrial storm water require NPDES permits, but some other storm water discharges do not require permits. To protect public health and aquatic life and assure that every facility treats wastewater, NPDES permits include the following terms and conditions.

- Site-specific effluent (or discharge) limitations.
- Standard and site-specific compliance monitoring and reporting requirements.
- Monitoring, reporting, and compliance schedules that must be met.

There are various methods used to monitor NPDES permit conditions. The permit will require the facility to sample its discharges and notify EPA and the state regulatory agency of these results. In addition, the permit will require the facility to notify EPA and the state regulatory agency when the facility determines it is not in compliance with the requirements of a permit. EPA and state regulatory agencies also send inspectors to facilities in order to determine if they are in compliance with the conditions imposed under their permits.

NPDES permits typically establish specific "effluent limitations" relating to the type of discharge. For process wastewaters, the permit incorporates the more stringent of technology-based limitations (either at 40 CFR Parts 405 through 471 or developed on a case-by-case basis according to the permit writer's best professional judgement) or water quality-based effluent limits (WQBELs). Some waste management units, such as surface impoundments, might have an NPDES permit to discharge wastewaters directly to surface waters. Other units might need an NPDES permit for storm-water discharges.

NPDES permits are issued by EPA or states with NPDES permitting authority. If you are located in a state with NPDES authority, you should contact the state directly to determine the requirements for your discharges. EPA's Office of Wastewater Management's Web page contains a complete, updated list of the states with approved NPDES permit programs, as well as a fact sheet and frequently asked questions about the NPDES permit program at <**cfpub.epa.gov/npdes**>. If a state does not have NPDES permitting authority, you should follow any state requirements for discharges and contact EPA to determine the applicable federal requirements for discharges.

When is an NPDES permit needed?

To answer questions about whether or not a facility needs to seek NPDES permit coverage, or to determine whether a particular program is administered by EPA or a state agency, contact your state or EPA regional storm-water office. Currently, 44 states and the U.S. Virgin Islands have federally-approved state NPDES permit programs. The following 6 states do not have final EPA approval: Alaska, Arizona, Idaho, Massachusetts, New Hampshire, and New Mexico.

(As of March 2001)

1. Storm-Water Discharges

EPA has defined 11 categories of "storm-water discharges associated with industrial activity" that require a permit to discharge to navigable waters (40 CFR Part 122.26 (b)(14)). These 11 categories are: 1) facilities subject to storm-water effluent limitations guidelines, new source performance standards (NSPS), or toxic pollutant effluent standards under 40 CFR Part 129 (specifies manufacturers of 6 specific pesticides), 2) "heavy" manufacturing facilities, 3) mining and oil and gas operations with "contaminated" storm-water discharges, 4) hazardous waste treatment, storage, or disposal facilities, 5) landfills, land application sites, and open dumps, 6) recycling facilities, 7) steam electric generating facilities, 8) transportation facilities, 9) sewage treatment plants, 10) construction operations disturbing five or more acres, and 11) other industrial facilities where materials are exposed to storm water. Nonhazardous waste landfills, waste piles, and land application units are included in category 5. Under a new Section 122.26(b)(15), storm water discharges from construction operations disturbing between one and five acres will be required to obtain a NPDES permit effective in March 2003. There will be, however, some waivers from permit requirements available.

To provide flexibility for the regulated community in acquiring NPDES storm-water discharge permits, EPA has two NPDES permit application options: individual permits and general permits.[2] Applications for indi-

[2] Initially, a group application option was available for facilities with similar activities to jointly submit a single application for permit coverage. A multi-sector general permit was then issued based upon information provided in the group applications. The group application option was only used during the initial stages of the program and is no longer available.

> ### What types of pollutants are regulated by NPDES?
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> Conventional pollutants are contained in the sanitary wastes of households, businesses, and industries. These pollutants include human wastes, ground-up food from sink disposals, and laundry and bath waters. Conventional pollutants include fecal coliform, oil and grease, total suspended solids (TSS), biochemical oxygen demand (BOD), and pH.
>
> Toxic pollutants are particularly harmful to animal or plant life. They are primarily grouped into organics (including pesticides, solvents, polychlorinated biphenyls (PCBs), and dioxins) and metals (including lead, silver, mercury, copper, chromium, zinc, nickel, and cadmium).
>
> Nonconventional pollutants are any additional substances that are not considered conventional or toxic that may require regulation. These include nutrients such as nitrogen and phosphorus.

vidual permits require the submission of a site drainage map, a narrative description of the site that identifies potential pollutant sources, and quantitative testing data for specific parameters. General permits usually involve the submission of a Notice of Intent (NOI) that includes only general information, which is neither industry-specific or pollutant-specific and typically do not require the collection of monitoring data. NPDES general storm-water permits typically require the development and implementation of storm-water pollution prevention plans and BMPs to limit pollutants in storm-water discharges.

The EPA has also issued the Multi-Sector General Permit (60 FR 50803; September 29, 1995) which covers 29 different industry sectors. The Agency reviewed, on a sector-by-sector basis, information concerning industrial activities, BMPs, materials stored outdoors, and end-of-pipe storm-water sampling data. Based on this review, EPA identified pollutants of concern in each industry sector, the sources of these pollutants, and the BMPs used to control them. The Multi-Sector General Permit requires the submission of an NOI, as well as development and implementation of a site-specific pollution prevention plan, as the basic storm-water control strategy for each industry sector.

2. *Discharges to Surface Waters*

Most surface impoundments that are addressed by the Guide are part of a facility's wastewater treatment process that results in an NPDES-permitted discharge to surface waters. The NPDES permit only sets pollution limits for the final discharge of treated wastewater. Generally, the NPDES permit would not establish any regulatory requirements regarding the design or operation of the surface impoundments that are part of the treatment process except that, once designed and constructed, a provision requires use of those treatment processes except in limited circumstances. Individual state environmental agencies, under their own statutory authorities, can impose requirements on surface impoundment design and operation.

B. National Pretreatment Program

1. *Description of the National Pretreatment Program*

For industrial facilities that discharge wastewaters to publicly owned treatment works (POTW) through domestic sewer lines, pretreatment of the wastewater may be required (40 CFR Part 403). Under the

National Pretreatment Program, EPA, states, and local regulatory agencies establish discharge limits to reduce the level of pollutants discharged by industry into municipal sewer systems. These limits control the pollutant levels reaching a POTW, improve the quality of the effluent and sludges produced by the POTW, and increase the opportunity for beneficial use of the end products (e.g., effluents, sludges, etc). Further information about industrial pretreatment and the National Pretreatment Program is available on the Office of Wastewater Management's Web page at <**cfpub.epa.gov/npdes/home.cfm?program_id=3**>.

POTWs are designed to treat domestic wastes and biodegradable commercial and industrial wastes. The CWA and EPA define the pollutants from these sources as "conventional pollutants" which includes those specific pollutants that are expected to be present in domestic discharges to POTWs. Commercial and industrial facilities can, however, discharge toxic pollutants that a treatment plant is neither designed nor able to remove. Such discharges, from both industrial and commercial sources, can cause serious problems at POTWs. The undesirable outcome of these discharges can be prevented by using treatment techniques or management practices to reduce or eliminate the discharge of these pollutants.

The act of treating wastewater prior to discharge to a POTW is commonly referred to as "pretreatment." The National Pretreatment Program provides the statutory and regulatory basis to require non-domestic dischargers to comply with pretreatment standards to ensure that the goals of the CWA are attained. The objectives of the National Pretreatment Program are to:

- Prevent the introduction of pollutants into POTWs which will interfere with the operation of a POTW, including interference with the disposal of municipal sludge.
- Prevent the introduction of pollutants into POTWs which will pass through the treatment works or otherwise be incompatible with such works.
- Improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges.

To help accomplish these objectives, the National Pretreatment Program is charged with controlling 126 priority pollutants from industries that discharge into sewer systems as described in the CWA, Section 307(a), and listed in 40 CFR Part 423 Appendix A. These priority pollutants fall into two categories, metals and toxic organics.

- The metals include lead, mercury, chromium, and cadmium. Such toxic metals cannot be destroyed or broken down through treatment or environmental degradation. They can cause various human health problems such as lead poisoning and cancer.
- The toxic organics include solvents, pesticides, dioxins, and polychlorinated biphenyls (PCBs). These can be cancer-causing and lead to other serious ailments, such as kidney and liver damage, anemia, and heart failure.

The objectives of the National Pretreatment Program are achieved by applying and enforcing three types of discharge standards: 1) prohibited discharge standards (provide for overall protection of POTWs), 2) categorical standards applicable to specific point source categories (provide for general protection of POTWs), and 3) local limits (address the water quality and other concerns at specific POTWs).

Prohibited Discharge Standards. All industrials users (IUs), whether or not subject to any other federal, state, or local pretreatment requirements, are subject to the general and specific prohibitions identified in 40 CFR Part 403.5 (a) and (b), respectively. General prohibitions forbid the discharge of any pollutant to a POTW that can pass through or cause interference. Specific prohibitions forbid the discharge of pollutants that pose fire or explosion hazards; corrosives; solid or viscous pollutants in amounts that will obstruct system flows; quantities of pollutants that will interfere with POTW operations; heat that inhibits biological activity; specific oils; pollutants that can cause the release of toxic gases; and pollutants that are hauled to the POTW (except as authorized by the POTW).

Categorical Standards. Categorical pretreatment standards are national, uniform, technology-based standards that apply to discharges to POTWs from specific industrial categories (e.g., battery manufacturing, coil coating, grain mills, metal finishing, petroleum refining, rubber manufacturing) and limit the discharge of specific pollutants. These standards are described in 40 CFR Parts 405 through 471.

Categorical pretreatment standards can be concentration-based or mass-based. Concentration- based standards are expressed as milligrams of pollutant allowed per liter of wastewater discharged (mg/l) and are issued where production rates for the particular industrial category do not necessarily correlate with pollutant discharges. Mass-based standards are generally expressed as a mass per unit of production (e.g., milligrams of pollutant per kilogram of product produced) and are issued where production rates do correlate with pollutant discharges. Thus, limiting the amount of water discharge (i.e., water conservation) is important to reducing the pollutant load to the POTW. For a few categories where reducing a facility's flow volume does not provide a significant difference in the pollutant load discharged, EPA has established both mass- and concentration-based standards. Generally, both a daily maximum limitation and a long-term average limitation (e.g., average daily values in a calendar month) are established for each regulated pollutant.

Local Limits. Federal regulations located at 40 CFR Parts 403.8 (f) (4) and 122.21 (j) (4) require authorities to evaluate the need for local limits and, if necessary, implement and enforce specific limits protective of that POTW. Local limits might be developed for pollutants such as metals, cyanide, BOD, TSS, oil & grease, and organics that can interfere with or pass through the treatment works, cause sludge contamination, or cause worker health and safety problems if discharged at excess levels.

All POTWs designed to accommodate flows of more than 5 million gallons per day and smaller POTWs with significant industrial discharges are required to establish pretreatment programs. The EPA Regions and states with approved pretreatment programs serve as approval authorities for the National Pretreatment Program. In that capacity, they review and approve requests for POTW pretreatment program approval or modification, oversee POTW program implementation, review requested modifications to categorical pretreatment standards, provide technical guidance to POTWs and IUs, and initiate enforcement actions against noncompliant POTWs and IUs.

2. Treatment of Waste at POTW Plants

A waste treatment works' basic function is to speed up the natural processes by which water is purified and returned to receiving lakes and streams. There are two basic stages in the treatment of wastes, primary and secondary. In the primary stage, solids are allowed to settle and are removed from wastewater. The secondary stage uses biological processes to further purify wastewater. Sometimes, these stages are combined into one operation. POTWs can also perform other "advanced treatment" operations to remove ammonia, phosphorus, pathogens and other pollutants in order to meet effluent discharge requirements.

Primary treatment. As sewage enters a plant for treatment, it flows through a screen, which removes large floating objects such as rags and sticks that can clog pipes or damage equipment. After sewage has been screened, it passes into a grit chamber, where cinders, sand, and small stones settle to the bottom. At this point, the sewage still contains organic and inorganic matter along with other suspended solids. These solids are minute particles that can be removed from sewage by treatment in a sedimentation tank. When the speed of the flow of sewage through one of these tanks is reduced, the suspended solids will gradually sink to the bottom, where they form a mass of solids called raw primary sludge. Sludge is usually removed from tanks by pumping, after which it can be further treated for use as fertilizer, or disposed of through incineration if necessary. To complete primary treatment, effluent from the sedimentation tank is usually disinfected with chlorine before being discharged into receiving waters. Sometimes chlorine is fed into the water to kill pathogenic bacteria and to reduce unpleasant odors.

Secondary treatment. The secondary stage of treatment removes about 85 percent of the organic matter in sewage by making use of the bacteria in it. The two principal techniques used in secondary treatment are trickling filters and the activated sludge process.

Trickling filters. A trickling filter is a bed of stones from three to six feet deep through which the sewage passes. More recently, interlocking pieces of corrugated plastic or other synthetic media have also been used in trickling beds. Bacteria gather and multiply on these stones until they can consume most of the organic matter in the sewage. The cleaner water trickles out through pipes for further treatment. From a trickling filter, the sewage flows to another sedimentation tank to remove excess bacteria. Disinfection of the effluent with chlorine is generally used to complete the secondary stage. Ultraviolet light or ozone are also sometimes used in situations where residual chlorine would be harmful to fish and other aquatic life.

Activated sludge. The activated sludge treatment process speeds up the work of the bacteria by bringing air and sludge, heavily laden with bacteria, into close contact with sewage. After the sewage leaves the settling tank in the primary stage, it is pumped into an aeration tank, where it is mixed with air and sludge loaded with bacteria and allowed to remain for several hours. During this time, the bacteria break down the organic matter into harmless by-products. The sludge, now activated with additional millions of bacteria and other tiny organisms, can be used again by returning it to the aeration tank for mixing with new sewage and ample amounts of air. From the aeration tank, the sewage flows to another sedimentation tank to remove excess bacteria. The final step is generally the addition of chlorine to the effluent.

Advanced treatment. New pollution problems have created additional treatment needs on wastewater treatment systems. Some pollutants can be more difficult to remove from water. Increased demands on the water supply only aggravate the problem. These challenges are being met through better and more complete methods of removing pollutants at treatment plants, or through prevention of pollution at the source (refer to

Chapter 3 – Integrating Pollution Prevention for more information). Advanced waste treatment techniques in use or under development range from biological treatment capable of removing nitrogen and phosphorus to physical-chemical separation techniques such as filtration, carbon adsorption, distillation, and reverse osmosis. These wastewater treatment processes, alone or in combination, can achieve almost any degree of pollution control desired. As waste effluents are purified to higher degrees by such treatment, the effluent water can be used for industrial, agricultural, or recreational purposes, or even as drinking water supplies.

III. Understanding Fate and Transport of Pollutants

A. How Do Pollutants Move From Waste Management Units To Surface Water?

1. *Overland Flow*

The primary means by which pollutants are transported to surface-water bodies is via overland flow or "runoff." Runoff to surface water is the amount of precipitation after all "losses" have been subtracted. Losses include infiltration into soils, interception by vegetation, depression storage and ponding, and evapotranspiration (i.e., evaporation from the soil and transpiration by plants).

There is a correlation between the pollutant loadings to surface water and the amount of precipitation (rainfall, snow, etc.) that falls on the watershed in which a waste management unit is located. In addition, the characteristics of the soil at a facility also influence pollutant loading to surface water. If, for example, the overland flow is diminished due to high soil infiltration, so is the transport of particulate pollutants to surface water. Also, if wastes are land applied and surface overland flow is generated by a rainfall event, a significant portion of pollutants can be moved over land into adjacent surface water.

A diagram representing rainfall transformation into runoff and other components of the hydrologic cycle is shown in Chapter 7: Section A–Assessing Risk. The first stage of runoff formation is condensation of atmospheric moisture into rain droplets or snowflakes. During this process, water comes in contact with atmospheric pollutants. The pollution content of rainwater can therefore reach high levels. In addition, rain water dis-

What is "runoff?"

Runoff is water or leachate that drains or flows over the land from any part of a waste management unit.

What is "run-on?"

Run-on is water from outside a waste management unit that flows into the unit. Run-on includes storm water from rainfall or the melting of snow or ice that falls directly on the unit, as well as the water that drains from adjoining areas.

solves atmospheric carbon dioxide and sulfur and nitrogen oxides, and acts as a weak acid after it hits the ground, reacting with soil and limestone formations. Overland flow begins after rain particles reach the earth's surface (note that during winter months runoff formation can be delayed by snowpack formation and subsequent melting). Rain hitting an exposed waste management unit will liberate and pick up particulates and pollutants from the unit and can also dissolve other chemicals it comes in contact with. Precipitation that flows into a waste management unit, called "run-on," can also free-up and subsequently transport pollutants out of the unit. Runoff carries the pollutants from the waste management unit as it flows downgradient following the natural contours of the watershed to nearby lakes, rivers, or wetland areas.

2. *Ground Water to Surface Water*

Ground water and surface water are fundamentally interconnected. In fact, it is often difficult to separate the two because they "feed" each other. As a result, pollutants can move from one media to another. Shallow water table aquifers interact closely with streams, sometimes discharging water into a stream or lake and sometimes receiving water from the stream or lake. Many rivers, lakes, and wetlands rely heavily on ground-water discharge as a source of water. During times of low precipitation, some bodies of water would not contain any water at all if it were not for ground-water discharge.

An unconfined aquifer that feeds a stream is said to provide the stream's "baseflow." Gravity is the dominant driving force in ground-water movement in unconfined aquifers. As such, under natural conditions, ground water moves "downhill" until it reaches the land surface at a spring or through a seep in the side or bottom of a river bed, lake, wetland, or other surface-water body. Ground water can also leave the aquifer via the pumping of a well. The process of ground water outflowing into a surface-water body or leaving the aquifer through pumping is called discharge.

Discharge from confined aquifers occurs in much the same way except that pressure, rather than gravity, is the driving force in moving ground water to the surface. When the intersection between the aquifer and the land's surface is natural, the pathway is called a spring. If discharge occurs through a well, that well is a "flowing artesian well."

3. *Air to Surface Water*

Pollutants released into the air are carried by wind patterns away from their place of origin. Depending on weather conditions and the chemical and physical properties of the pollutants, pollutants can be carried significant distances from their source and can undergo physical and chemical changes as they travel. Some of these chemical changes include the formation of new pollutants such as ozone, which is formed from nitrogen oxides (NO_x) and hydrocarbons.

Atmospheric deposition occurs when pollutants in the air fall on the land or surface waters. When pollutants are deposited in snow, fog, or rain, the process is called wet deposition, while the deposition of pollutants as dry particles or gases is called dry deposition. Pollutants can be deposited into water bodies either directly from the air onto the surface of the water, or through indirect deposition, where the pollutants settle on the land and are then carried into a water body by runoff.

Any pollutant that is emitted into the air can become a surface-water problem due to deposition. Some of the common pollutants that can be transported to surface-water bodies via air include different forms of nitrogen, mercury, copper, polychlorinated biphenols (PCBs), polycyclic aromatic hydrocarbons (PAHs), chlordane, dieldrin, lead, lindane, polycyclic organic matter (POM), dioxins, and furans.

B. What Happens When Pollutants Enter Surface Water?

All pollutants entering surface water via runoff, ground-water infiltration, or air transport have an effect on the aquatic ecosystem. Additive and synergistic effects are also factors because many different pollutants can enter a surface-water body from diverse sources and activities. As such, solutions to water quality problems are best achieved by looking at all activities and inputs to surface water in a watershed.

Surface-water ecosystems (i.e., rivers, lakes, wetlands, estuaries) are considered to be in a dynamic equilibrium with their inputs and surroundings. These ecosystems can be divided into two components, the biotic (living) and abiotic (nonliving). Pollutants are continually moving between the two. For example, pollutants can move from the abiotic environment (i.e., the water column) into aquatic organisms, such as fish. The intake of the pollutant can occur as water moves across the gills or directly through the skin. Toxic pollutants can accumulate in fish (known as bioaccumulation), as the fish uptakes more of the pollutant than it can metabolize or excrete. Pollutants can eventually concentrate in an organism to a level where death results. At that point, the pollutants will be released back into the abiotic environment as the organism decays.

The Dissolved Oxygen Problem

The dissolved oxygen balance is an important water quality consideration for streams and estuaries. Dissolved oxygen is the most important parameter for protecting fish and other aquatic organisms. Runoff with a high concentration of biodegradable organics (organic matter) can have a serious effect on the amount of dissolved oxygen in the water. Low dissolved oxygen levels can be very detrimental to fish. The content of organic matter in waste discharges is commonly expressed as the biochemical oxygen demand (BOD) load. Organic matter can come from a variety of sources, including waste management units. When runoff containing organic matter is introduced into receiving waters, decomposers immediately begin to breakdown the organic matter using dissolved oxygen to do so. Further, if there are numerous inputs of organic matter into a single water body, for example a stream, the effects will be additive (i.e., more and more dissolved oxygen will be removed from the stream as organic matter is added along the stream reach and decomposes). This is also an example of how an input that might not be considered a pollutant (i.e., organic matter) can lead to harmful effects due to the naturally occurring process within a surface-water body.

Pollutants can also move within the abiotic environment, as for example, between water and its bottom sediments. Pollutants that are attached to soil particles being carried downstream will be deposited on the bottom of the streambed as the particles fall out of the water column. In this manner, pollutants can accumulate in areas of low flow. Thus, it is obvious that the hydrodynamical, biological, and chemical processes in aquatic systems cannot be separated and must be addressed simultaneously when considering pollutant loads and impacts to surface water. Table 1 presents some additional information on the biological and chemical processes that occur in water bodies.

C. Pollutants Of Concern

As you assess the different types of best management practices (BMPs) that can be used at waste management units to protect surface waters (discussed in Section IV of this chapter), you should also identify the pollutants in the unit that pose the greatest threats to surface water. Factors to consider include the solubility of the constituents in the waste management unit, how easily these potential pollutants can be mobilized, degradation rates, vapor pressures, and biochemical decay coefficients of the pollutants and any other factors that could encourage their release into the environment.

While all pollutants can become toxic at high enough levels, there are a number of compounds that are toxic at relatively low levels. These pollutants have been designated by the EPA as priority pollutants. The list of priority pollutants is included in Table 2. The list of priority pollutants is continuously under review by EPA and is periodically updated. The majority of pollutants on the list are classified as organic chemicals. Others are heavy metals which are being mobilized into the environment by human activities at rates greatly exceeding those of natural geological processes. Several of the priority pollutants are also considered carcinogenic (i.e., they can increase the risk of cancer to the human population or to aquatic organisms, such as fish). Priority pollutants of particular concern for surface-water bodies include:

- Metals, such as cadmium, copper, chromium, lead, mercury, nickel, and zinc, that arise from industrial operations, mining, transportation, and agricultural use.
- Organic compounds, such as pesticides, PCBs, solvents, petroleum hydrocarbons, organometallic compounds, phenols, formaldehyde, and biochemical methylation of metals in aquatic sediments.
- Dissolved gases, such as chlorine and ammonium.
- Anions, such as cyanides, fluorides, sulfides, and sulphates.
- Acids and alkalis.

IV. Protecting Surface Waters

A. Controls to Address Surface-Water Contamination from Overland Flow

Protecting surface water entails preventing storm-water contamination during both the construction of a waste management unit and the operational life of the unit. During construction the primary concern is sediment eroding from exposed soil surfaces. Temporary sediment and erosion control measures, such as silt fences around construction perimeters, straw bales around storm-water inlets, and seeding or straw covering of exposed slopes, are typically used to limit and manage erosion. States or local

Table 1. Biological and Chemical Processes Occurring in Surface-Water Bodies

After pollutants are transported to lakes, rivers, and other water bodies, they can be subject to a variety of biological and chemical processes that affect how they will interact and impact the aquatic ecosystem. These processes determine how pollutants are mobilized, degraded, or released into the biotic and abiotic environments.

Metabolism of a toxicant consists of a series of chemical transformations that take place within an organism. A wide range of enzymes act on toxicants, that can increase water solubility, and facilitate elimination from the organism. In some cases, however, metabolites can be more toxic than their parent compound. Sullivan. 1993. *Environmental Regulatory Glossary,* 6th Ed. Government Institutes.

Bioaccumulation is the uptake and sequestration of pollutants by organisms from their ambient environment. Typically, the concentration of the substance in the organism exceeds the concentration in the environment since the organism will store the substance and not excrete it. Phillips. 1993. In: Calow (ed), *Handbook of Ecotoxicology,* Volume One. Blackwell Scientific Publications.

Biomagnification is the concentration of certain substances up a food chain. It is a very important mechanism in concentrating pesticides and heavy metals in organisms such as fish. Certain substances such as pesticides and heavy metals move up the food chain, work their way into a river or lake and are eaten by large birds, other animals, or humans. The substances become concentrated in tissues or internal organs as they move up the chain. Sullivan. 1993. *Environmental Regulatory Glossary,* 6th Ed. Government Institutes.

Biological degradation is the decomposition of a substance into more elementary compounds by action of microorganisms such as bacteria. Sullivan. 1993. *Environmental Regulatory Glossary,* 6th Ed. Government Institutes.

Hydrolysis is a chemical process of decomposition in which the elements of water react with another substance to yield one or more new substances. This transformation process changes the chemical structure of the substance. Sullivan. 1993. *Environmental Regulatory Glossary,* 6th Ed. Government Institutes.

Precipitation is a chemical or physical change whereby a pollutant moves from a dissolved form in a solution to a solid or insoluble form and subsequently drops out of the solution. Precipitation reduces the mobility of constituents, such as metals and is not generally reversible. Boulding. 1995. *Soil, Vadose Zone, and Ground-Water Contamination: Assessment, Prevention, and Remediation.*

Oxidation/Reduction (Redox) process is a complex of biochemical reactions in sediment that influences the valence state of elements (and their ions) found in sediments. Under anaerobic conditions the overall process shifts to a reducing condition. The chemical properties for elements can change substantially with changes in the oxidation state. Sullivan. 1993. *Environmental Regulatory Glossary,* 6th Ed. Government Institutes.

Photochemical process is the chemical changes brought about by the radiant energy of the sun acting upon various polluting substances. Sullivan. 1993. *Environmental Regulatory Glossary,* 6th Ed. Government Institutes.

Table 2. Priority Pollutants[3]

001	Acenaphthene	043	Methylene chloride	085	Vinyl chloride
002	Acrolein	044	Methyl chloride	086	Aldrin
003	Acrylonitrile	045	Methyl bromide	087	Dieldrin
004	Benzene	046	Bromoform	088	Chlordane
005	Benzidine	047	Dichlorobromomethane	089	4,4-DDT
006	Carbon tetrachloride	048	Chlorodibromomethane	090	4,4-DDE
007	Chlorobenzene	049	Hexachlorobutadiene	091	4,4-DDD
008	1,2,4-trichlorobenzene	050	Hexachlorocyclopentadiene	092	Alpha-endosulfan
009	Hexachlorobenzene	051	Isophorone	093	Beta-endosulfan
010	1,2-dichloroethane	052	Naphthalene	094	Endosulfan sulfate
011	1,1,1-trichloreothane	053	Nitrobenzene	095	Endrin
012	Hexachloroethane	054	2-nitrophenol	096	Endrin aldehyde
013	1,1-dichloroethane	055	4-nitrophenol	097	Heptachlor
014	1,1,2-trichloroethane	056	2,4-dinitrophenol	098	Heptachlor epoxide
015	1,1,2,2-tetrachloroethane	057	4,6-dinitro-o-cresol	099	Alpha-BHC
016	Chloroethane	058	N-nitrosodimethylamine	100	Beta-BHC
017	Bis(2-chloroethyl) ether	059	N-nitrosodiphenylamine	101	Gamma-BHC
018	2-chloroethyl vinyl ethers	060	N-nitrosodi-n-propylamine	102	Delta-BHC
019	2-chloronaphthalene	061	Pentachlorophenol	103	PCB–1242
020	2,4,6-trichlorophenol	062	Phenol	104	PCB–1254
021	Parachlorometa cresol	063	Bis(2-ethylhexyl) phthalate	105	PCB–1221
022	Chloroform	064	Butyl benzyl phthalate	106	PCB–1232
023	2-chlorophenol	065	Di-N-Butyl Phthalate	107	PCB–1248
024	1,2-dichlorobenzene	066	Di-n-octyl phthalate	108	PCB–1260
025	1,3-dichlorobenzene	067	Diethyl Phthalate	109	PCB–1016
026	1,4-dichlorobenzene	068	Dimethyl phthalate	110	Toxaphene
027	3,3-dichlorobenzidine	069	Benzo(a) anthracene	111	Antimony
028	1,1-dichloroethylene	070	Benzo(a)pyrene	112	Arsenic
029	1,2-trans-dichloroethylene	071	Benzo(b) fluoranthene	113	Asbestos
030	2,4-dichlorophenol	072	Benzo(b) fluoranthene	114	Beryllium
031	1,2-dichloropropane	073	Chrysene	115	Cadmium
032	1,2-dichloropropylene	074	Acenaphthylene	116	Chromium
033	2,4-dimethylphenol	075	Anthracene	117	Copper
034	2,4-dinitrotoluene	076	Benzo(ghi) perylene	118	Cyanide, Total
035	2,6-dinitrotoluene	077	Fluorene	119	Lead
036	1,2-diphenylhydrazine	078	Phenanthrene	120	Mercury
037	Ethylbenzene	079	Dibenzo(,h) anthracene	121	Nickel
038	Fluoranthene	080	Indeno (1,2,3-cd) pyrene	122	Selenium
039	4-chlorophenyl phenyl ether	081	Pyrene	123	Silver
040	4-bromophenyl phenyl ether	082	Tetrachloroethylene	124	Thallium
041	Bis(2-chloroisopropyl) ether	083	Toluene	125	Zinc
042	Bis(2-chloroethoxy) methane	084	Trichloroethylene	126	2,3,7,8-TCDD

[3] The list of pollutants is current as of the Federal Register dated April 2, 2001.

municipalities often require the use of sediment and erosion controls at any construction site disturbing greater than a certain number of acres, and can have additional requirements in especially sensitive watersheds. You should consult with the state and local regulatory agencies to determine the sediment and erosion control requirements for construction.

Once a waste management unit has been constructed, permanent run-on and runoff controls are necessary to protect surface water. Run-on controls are designed to prevent storm water from entering the active areas of units. If run-on is not prevented from entering active areas, it can seep into the waste and increase the amount of leachate that must be managed. It can also deposit pollutants from nearby sites, such as pesticides from adjoining farms, further burdening treatment systems. Excessive run-on can also damage earthen containment systems, such as dikes and berms. Run-on that contacts the waste can carry pollutants into receiving waters through overland runoff or into ground water through infiltration. You can divert run-on to the waste management unit by taking advantage of natural contours in the land or by constructing ditches or berms designed to intercept and drain storm water away from the unit. Run-on diversion systems should be designed to handle the peak discharge of a design storm event (e.g., a 24-hour, 25-year storm[4]). Also note that surface impoundments should be designed with sufficient freeboard and adequate capacity to accommodate not only waste, but also precipitation and run-on.

Runoff controls can channel, divert, and convey storm water to treatment facilities or, if appropriate, to other intended discharge points. Runoff from landfills, land treatment units, or waste piles should be managed as a potentially contaminated material. The runoff from active areas of a landfill or waste pile should be managed as leachate. You should design a leachate collection and removal system to handle the potentially contaminated runoff, in addition to the leachate that might be generated by the unit. You should segregate noncontact runoff to reduce the volume that will need to be treated as leachate. The Multi-Sector General Permit does not authorize discharges of leachate which includes storm water that comes in contact with waste. The discharge of leachate would be regulated under either an individually drafted NPDES permit with site- specific discharge limitations, or an alternative NPDES general permit if one is available. Note that for land application sites, runoff from the site can also adversely affect nearby surface water if pollutants are picked up and carried overland.

BMPs are measures used to reduce or eliminate pollutant releases to surface waters via overland flow. They fall into three categories, baseline, activity-specific, and site-specific, and can take the form of a process, activity, or physical structure. The use of

Why are "run-on" controls necessary?

Run-on controls are designed to prevent: 1) contamination of storm water, 2) erosion that can damage the physical structure of units, 3) surface discharge of waste constituents, 4) creation of leachate, and 5) already contaminated surface water from entering the unit.

What is the purpose of a "runoff" control system?

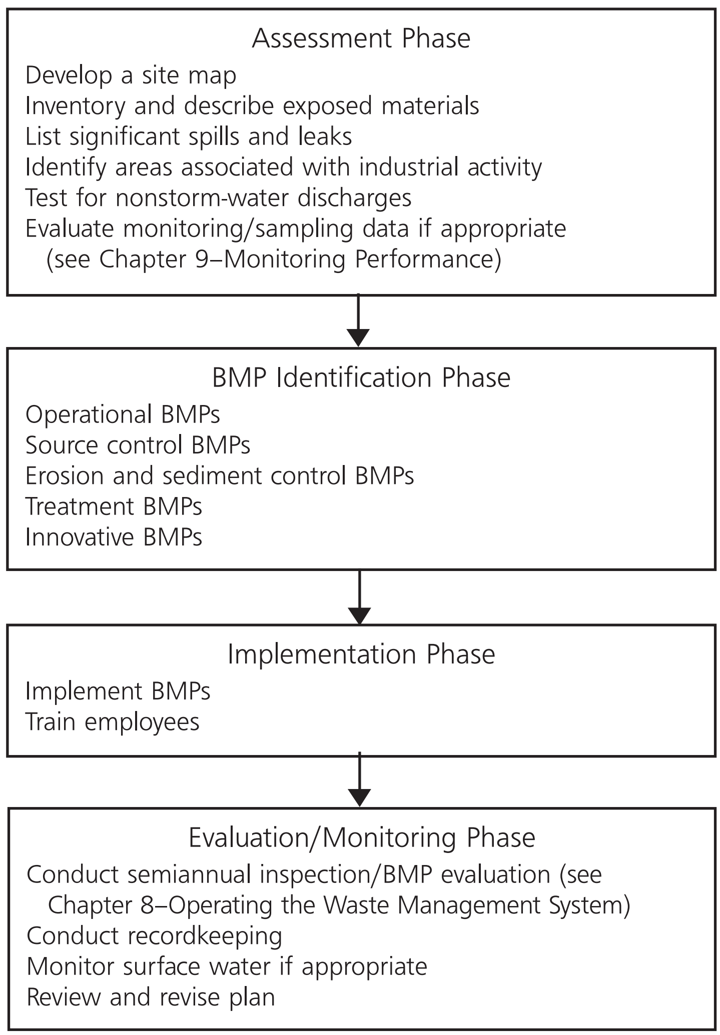
Runoff control systems are designed to collect and control at a minimum the water flow resulting from a storm event of a specified duration, such as a 24-hour, 25-year storm event.

[4] This discharge is the amount of water resulting from a 24-hour rainfall event of a magnitude with a 4 percent statistical likelihood of occurring in any given year (i.e, once every 25 years). Such an event might not occur in a given 25-year period, or might occur more than once during a single year.

BMPs to protect surface water should be considered in both the design and operation of a waste management unit. Before identifying and implementing BMPs, you should assess the potential sources of storm-water contamination including possible erosion and sediment discharges caused by storm events. A thorough assessment of a waste management unit involves several steps including creating a map of the waste management unit area; considering the design of the unit; identifying areas where spills, leaks, or discharges could or do occur; inventorying the types of wastes contained in the unit; and reviewing current operating practices (refer to Chapter 8–Operating the Waste Management System for more information). Figure 1 illustrates the process of identifying and selecting the most appropriate BMPs.

Designing a storm-water management system to protect surface water involves knowledge of local precipitation patterns, surrounding topographic features, and geologic conditions. You should consider sampling runoff to ascertain the quantity and concentration of pollutants being discharged. (Refer to the Chapter 9–Monitoring Performance for more information). Collecting and evaluating this type of information can help you to select the most appropriate BMPs to prevent or control pollutant discharges. The same considerations (e.g., types of wastes to be contained in the unit, precipitation patterns, local topography and geology) should be made while designing and constructing a new waste management unit to ensure that the proper baseline, activity-specific, and site-specific BMPs are implemented and installed from the start of operations. After assessing the potential and existing sources of storm-water contamination, the next step is to select appropriate BMPs to address these contamination sources.

Figure 1. BMP Identification and Selection Flow Chart
Recommended Steps



Adapted from U.S. EPA, 1992e.

1. Baseline BMPs

These practices are, for the most part, inexpensive and relatively simple. They focus on preventing circumstances that could lead to surface-water contamination before it can occur. Many industrial facilities already have these measures in place for product loss prevention, accident and fire prevention, worker health and safety, or compliance with other regulations (refer to Chapter 8–Operating the Waste Management System for more information). Baseline BMPs include the measures summarized below.

Good housekeeping. A clean and orderly work environment is an effective first step toward preventing contamination of run-on and runoff. You should conduct an inventory of all materials and store them so as to prevent leaks and spills and, if appropriate, maintain them in areas protected from precipitation and other elements.

Preventive maintenance. A maintenance program should be in place and should include inspection, upkeep, and repair of the waste management unit and any measures specifically designed to protect surface water.

Visual inspections. Inspections of surface-water protection measures and waste management unit areas should be conducted to uncover potential problems and identify necessary changes. Areas deserving close attention include previous spill locations; material storage, handling, and transfer areas; and waste storage, treatment, and disposal areas. Any problems such as leaks or spills that could lead to surface-water contamination should be corrected as soon as practical.

Spill prevention and response. General operating practices for safety and spill prevention should be established to reduce accidental releases that could contaminate run-on and runoff. Spill response plans should be developed to prevent any accidental releases from reaching surface water.

Mitigation practices. These practices contain, clean-up, or recover spilled, leaked, or loose material before it can reach surface water and cause contamination. Other BMPs should be considered and implemented to avoid releases, but procedures for mitigation should be devised so that unit personnel can react quickly and effectively to any releases that do occur. Mitigation practices include sweeping or shoveling loose waste into appropriate areas of the unit; vacuuming or pumping spilled materials into appropriate treatment or handling systems; cleaning up liquid waste or leachate using sorbents such as sawdust; and applying gelling agents to prevent spilled liquid from flowing towards surface water.

Training employees to operate, inspect, and maintain surface-water protection measures is itself considered a BMP, as is keeping records of installation, inspection, maintenance, and performance of surface-water protection measures. For more information on employee training and record keeping, refer to Chapter 8–Operating the Waste Management System.

2. Activity-Specific BMPs

After assessment and implementation of baseline BMPs, you should also consider planning for activity-specific BMPs. Like baseline BMPs, they are often procedural rather than structural or physical measures, and they are often inexpensive and easy to implement. In the BMP manual for industrial facilities, *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices* (U.S. EPA, 1992f), EPA developed activity-specific BMPs for nine industrial activities, including waste management. The BMPs that are relevant to waste management are summarized below.

Preventing waste leaks and dust emissions due to vehicular travel. To prevent leaks, you should ensure that trucks moving waste into and around a waste management unit have baffles (if they carry liquid waste) or sealed gates, spill guards, or tarpaulin covers (if the waste is solid or semisolid). To minimize tracking dust off site where it can be picked up by storm water, wash trucks in a curbed truck wash area where wash water is captured and properly handled. For more information on these topics, consult Chapter 8–Operating the Waste Management System . You should be aware that washwater from vehicle and equipment cleaning is considered to be "process wastewater," and is not eligible for discharge under the Multi-Sector General Permit program for industrial storm-water discharges. Such discharges would require coverage under either a site-specific individual NPDES permit or an NPDES general storm-water permit.

For land application, choosing appropriate slopes. You should minimize runoff by designing a waste management unit site with slopes less than six percent. Moderate slopes help reduce storm-water runoff velocity which encourages infiltration and reduces erosion and sedimentation. Note that storm-water discharges from land application units are regulated under the Multi-Sector General Permit program.

3. Site-Specific BMPs

In addition to baseline and activity-specific BMPs, you should also consider site-specific BMPs, which are more advanced measures tailored to specific pollutant sources at a particular waste management unit and usually consist of the installation of structural or physical measures. These site-specific BMPs can be grouped into five areas: flow diversion, exposure minimization, erosion and sedimentation prevention, infiltration, and other prevention practices. For many of the surface-water protection measures described in this section, it is important to design for an appropriate storm event (i.e., structures that control run-on and runoff should be designed for the discharge of a 24-hour, 25-year storm event).

When selecting and designing surface-water protection measures or systems, you should consult state, regional, and local watershed management organizations. Some of these organizations maintain management plans devised at the overall watershed level that address storm-water control. Thus, these agencies might be able to offer guidance in developing surface-water protection systems for optimal coordination with other discharges in the watershed. Again, after site-specific BMPs have been installed, you should evaluate the effectiveness of the selected BMPs on a regular basis to ensure that they are functioning properly .

BMP Maintenance

BMPs must be maintained on a regular basis to ensure adequate surface-water protection. Maintenance is important because storms can damage surface-water protection measures such as storage basin embankments or spillways. Runoff can also cause sediments to settle in storage basins or ditches and can carry floatables (i.e., tree branches, lumber, leaves, litter) to the basin. Facilities might need to repair storm-water controls and periodically remove sediment and floatables.

a. Flow Diversion

Flow diversion can be used to protect surface water in two ways. First, it can channel storm water away from waste management units to minimize contact of storm water with waste. Second, it can carry polluted or potentially polluted materials to treatment facilities. Flow diversion mechanisms include storm-water conveyances and diversion dikes.

Storm-Water Conveyances (Channels, Gutters, Drains, and Sewers)

Storm-water conveyances, such as channels, gutters, drains, and sewers, can prevent storm-water run-on from entering a waste management unit or runoff from leaving a unit untreated. Some conveyances collect storm water and route it around waste management units or other waste containment areas to prevent contact with the waste, which might otherwise contaminate storm water with pollutants. Other conveyances collect water that potentially came into contact with the waste management unit and carry it to a treatment plant (or possibly back to the unit for reapplication in the case of land application units, some surface impoundments, and leachate-recirculating landfills). Conveyances should not mix the stream of storm water diverted around the unit with that of water that might have contacted waste. Remember, storm water that contacts waste is considered leachate and can only be discharged in accordance with an NPDES permit other than the Multi-Sector General Permit.

Storm-water conveyances can be constructed of or lined with materials such as concrete, clay tile, asphalt, plastic, metal, riprap, compacted soil, and vegetation. The material used will vary depending on the use of the conveyance and the expected intensity of storm-water flow. Storm-water conveyances should be designed with a capacity to accept the estimated storm-water flow associated with the selected design storm event. Section V of this chapter discusses methods for determining storm water flow.

What are some advantages of conveyances?

Conveyances direct storm-water flows around industrial areas, waste management units, or other waste containment areas to prevent temporary flooding; require little maintenance; and provide long-term control of storm-water flows.

What are some disadvantages of conveyances?

Conveyances require routing through stabilized structures to minimize erosion. They also can increase flow rates, might be impractical if there are space limitations, and might not be economical.

Diversion Dikes

Diversion dikes, often made with compacted soil, direct run-on away from a waste management unit. Dikes are built uphill from a unit and usually work with storm-water conveyances to divert storm water from the unit. To minimize the potential for erosion, diversion dikes are often constructed to redirect runoff at a shallow slope to minimize its velocity. A similar means of flow diversion is grading the area around the waste management unit to keep storm water away from the area, instead of or in addition to using diversion dikes to redirect water that would otherwise flow into these areas. In planning for the installation of dikes, you should consider the slope of the drainage area, the height of the dike, the size of the flow it will need to divert, and the type of conveyance that will be used with the dike.

b. *Exposure Minimization*

Like flow diversion, exposure minimization practices, such as curbing, diking, and covering can reduce contact of storm water with waste. They often are small structures immediately covering or surrounding a higher risk area, while flow diversion practices operate on the scale of an entire waste management unit.

Curbing and Diking

These are raised borders enclosing areas where liquid spills can occur. Such areas could include waste transfer points in land application, truck washes, and leachate management areas at landfills and waste piles. The raised dikes or curbs prevent spilled liquids from flowing to surface waters, enabling prompt cleanup of only a small area.

Covering

Erecting a roof, tarpaulin, or other permanent or temporary covering (see Figure 2) over the active area of a landfill or waste transfer location can keep precipitation from falling directly on waste materials and prevent run-on from occurring. If temporary coverings are used, you should ensure that sufficient weight is attached to prevent wind from moving the cover, and to repair or replace the cover material if holes or leaks develop.

c. *Erosion and Sedimentation Prevention*

Erosion and sedimentation practices serve to limit erosion (the weathering of soil or rock particles from the ground by wind, water, or human activity) and to prevent particles that are eroded from reaching surface waters as sediment. Erosion and sedimentation can threaten aquatic life, increase treatment costs for downstream water treatment plants, and impede recreational and navigational uses of waterways. Erosion and sedimentation are of particular concern at waste management units because the sediment can be contaminated with waste constituents and because erosion can undercut or otherwise weaken waste containment structures. Practices such as vegetation, interceptor dikes, pipe slope drains, silt fences, storm drain inlet protection, collection and sedimentation basins, check dams, terraces and benches, and outlet protection can help limit erosion and sedimentation.

What are some advantages of diversion dikes?

Diversion dikes limit storm-water flows over industrial site areas; can be economical, temporary structures when built from soil onsite; and can be converted from temporary to permanent at any time.

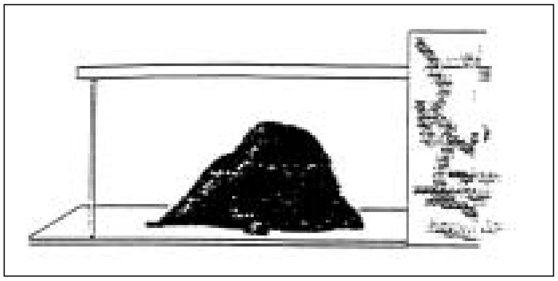
What are some disadvantages of diversion dikes?

Diversion dikes are not suitable for large drainage areas unless there is a gentle slope and might require maintenance after heavy rains.

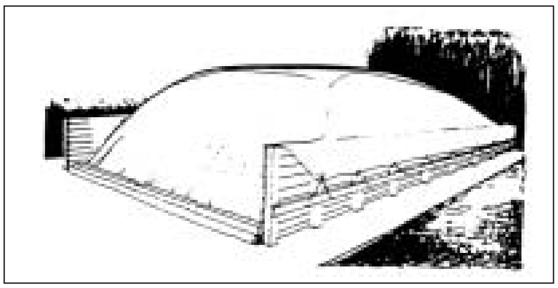
Vegetation

Erosion and sedimentation can be reduced by ensuring that areas where storm water is likely to flow are vegetated. Vegetation slows erosion and sedimentation by shielding soil surfaces from rainfall, improving the soil's water storage capacity, holding soil in place, slowing runoff, and filtering out sediment. One method of providing vegetation is to preserve natural growth. This is achieved by

Figure 2. Coverings



Roof, overhang, or other permanent structure



Tarp or other covering

From U.S. EPA, 1992e.

managing the construction of the waste management unit to minimize disturbance of surrounding grass and plants. If it is not possible to leave all areas surrounding a unit undisturbed, preserve strips of existing vegetation as buffer zones in strategically chosen areas of the site where erosion and sediment control is most needed, such as on steep slopes uphill of the unit and along stream banks downhill from the unit. If it is not possible to leave sufficient buffer zones of existing vegetation, you should create buffer zones by planting such areas with new vegetation.

Temporary or permanent seeding of erodible areas is another means of controlling erosion and sedimentation using vegetation. Permanent seeding, often of grass, is appropriate for establishing long-term ground cover after construction and other land-disturbing activities are complete. Temporary seeding can help prevent erosion and sedimentation in areas that are exposed but will not be disturbed again for a considerable time. These areas include soil stockpiles, temporary roadbanks, and dikes. Local regulations might require temporary seeding of areas that would otherwise remain exposed beyond a certain period of time. You should consult local officials to determine whether such requirements apply. Seeding might not be feasible for quickly establishing cover in arid climates or during nongrowing seasons in other climates. Sod, although more expensive, can be more tolerant of these conditions than seed and establish a denser grass cover more quickly. Compost used in combination with seeding can also be used effectively to establish vegetation on slopes.

Physical and chemical stabilization, and various methods of providing cover are also often considered in conjunction with vegetative measures or when vegetative measures cannot be used. Physical stabilization is appropriate where stream flow might be increased due to construction or other activities associated with the waste management unit and where vegetative measures are not practical. Stream-bank stabilization might involve the reinforcement of stream banks with stones, concrete or asphalt, logs, or gabions (i.e., structures formed from crushed rock encased in wire mesh). Methods of providing cover such as mulching, compost, matting, and netting can be used to cover surfaces that are steep, arid, or otherwise unsuitable for planting. These methods also can work in conjunction with planting to stabilize and protect seeds. (Mattings are sheets of mulch that are more stable than loose mulch chips. Netting is a mesh of jute, wood fiber, plastic, paper, or cotton that can hold mulch on the ground or stabilize soils. These measures are sometimes used with seeding to provide insulation, protect against birds, and hold seeds and soil in place.) Chemical stabilization (also known as chemical mulch, soil binder, or soil palliative) can hold the soil in place and protect against erosion by spraying vinyl, asphalt, or rubber onto soil surfaces. Erosion and sediment control is immediate upon spraying and does not depend on climate or season. Stabilizer should be applied according to manufacturer's instructions to ensure that water quality is not affected. Coating large areas with thick layers of stabilizer, however, can create an impervious surface and speed runoff to downgradient areas and should be avoided.

Interceptor Dikes and Swales

Dikes (ridges of compacted soil) and swales (excavated depressions in which storm water flows) work together to prevent entry of run-on into erodible areas. A dike is built across a slope upgradient of an area to be protected, such as a waste management unit, with a swale just above the dike. Water flows down the slope, accumulates in the swale, and is blocked from exiting it by the dike. The swale is graded to direct water slowly downhill across the slope to a stabilized outlet structure. Since flows are concentrated in the swale, it is important to vegetate the swale to prevent erosion of its channel and to grade it so that predicted flows will not damage the vegetation.

Pipe Slope Drains

Pipe slope drains are flexible pipes or hoses used to traverse a slope that is already damaged or at high risk of erosion. They are often used in conjunction with some means of blocking water flow on the slope, such as a dike. Water collects against the dike and is then channeled to one point along the dike where it enters the pipe, which conveys it downhill to a stabilized (usually riprap-lined) outlet area at the bottom of the slope. You should ensure that pipes are of adequate size to accommodate the design storm event and are kept clear of clogs.

Silt Fences, Straw Bales, and Brush Barriers

Silt fences and straw bales (see Figures 3 and 4) are temporary measures designed to capture sediment that has already eroded and reduce the velocity of storm water. Silt fences and straw bales should not be considered permanent measures unless fences are maintained on a routine basis and straw bales are replaced regularly. They could be used, for example, during construction of a waste management unit or on a final cover before permanent grass growth is established.

Silt fences consist of geotextile fabric supported by wooden posts. These fences slow the flow of storm water and retain sediment as the water filters through the fabric. If properly installed, straw bales perform a similar function. Straw bales should be placed end to end (with no gaps in between) in a shallow, excavated trench and staked into place. Silt fences and straw bales limit sediment from entering receiving waters if properly maintained. Both measures require frequent inspection and maintenance, including checking for channels eroded beneath the fence or bales, removing

What are some advantages of silt fences, straw bales, and brush barriers?

They prevent eroded materials from reaching surface waters and prevent downstream damage from sediment deposits at minimal cost.

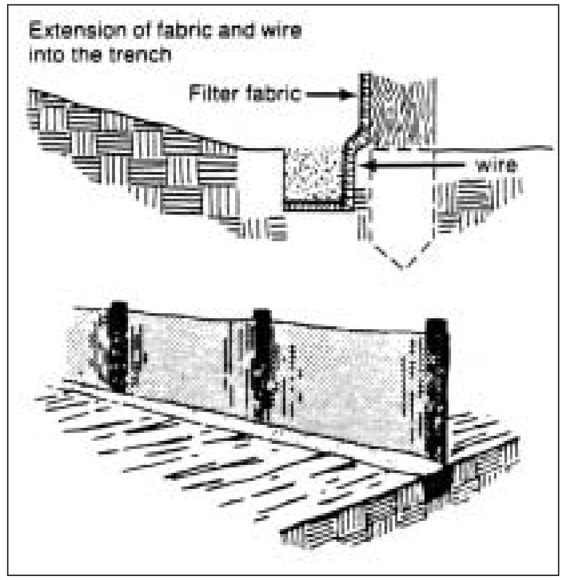
What are some disadvantages of silt fences, straw bales, and brush barriers?

These measures are not appropriate for streams or large swales and pose a risk of washouts if improperly installed.

accumulated sediment, and replacing damaged or deteriorated sections.

Brush barriers work like silt fences and straw bales but are constructed of readily available materials. They consist of brush and other vegetative debris piled in a row and are often covered with filter fabric to hold them in place and increase sediment interception. Brush barriers are inexpensive due to their reuse of material that is likely available from clearing the site. New vegetation often grows in the organic material of a brush barrier, helping anchor the barrier with roots. Depending on the material used, it might be possible to leave a former brush barrier in place and allow it to biodegrade, rather than remove it.

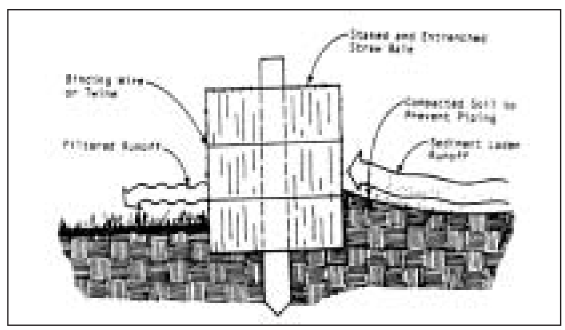
Figure 3. Silt Fence



Bottom: Perspective of silt fence. Top: Cross-section detail of base of silt fence.

From U.S. EPA, 1992e.

Figure 4. Straw Bale



From U.S. EPA, 1992e.

Storm Drain Inlet Protection

Filtering measures placed around inlets or drains to trap sediment are known as inlet protection (see Figure 5). These measures prevent sediment from entering inlets or drains and possibly making their way to the receiving waters into which the storm drainage system discharges. Keeping sediment out of storm-water drainage systems also serves to prevent clogging, loss of capacity, and other problems associated with siltation of drainage structures. Inlet protection methods include sod, excavated areas for settlement of sediment, straw bales or filter fences, and gravel or stone with wire mesh. These measures are appropriate for inlets draining small areas where soil will be disturbed. Some state or local jurisdictions require installation of these measures before disturbance of more than a certain acreage of land begins. Regular maintenance to remove accumulated sediment is important for proper operation.

Collection and Sedimentation Basins

A collection or sedimentation basin (see Figure 6) is an area that retains runoff long enough to allow most of the sediment to settle out and accumulate on the bottom of the basin. Since many pollutants are attached to suspended solids, they will also settle out in the basin with the sediment. The quantity of sediment removed will depend on basin volume, inlet and outlet configuration, basin depth and shape, and retention time. Regular maintenance and dredging to remove accumulated sediment and to minimize growth of aquatic plants that can reduce effectiveness is critical to the operation of basins. All dredged materials, whether they are disposed or reused, should be managed appropriately.

Basins can also present a safety hazard. Fences or other measures to prevent unwanted public access to the basins and their associated inlet and outlet structures are prudent safety precautions. In designing collection or sedimentation basins (a form of surface impoundment), consider storm- water flow, sediment and pollutant loadings, and the characteristics of expected pollutants. In the case of certain pollutants, it might be appropriate to line the basins to protect the ground water below. Lining a basin with concrete also facilitates maintenance by allowing dredging vehicles to drive into a drained basin and remove accumulated sediment. Poor implementation of baseline and activity-specific BMPs can result in high sediment and pollutant loads, leading to unusually frequent dredging of settled materials. For this reason, when operating sedimentation basins, it is important that baseline and activity-specific BMPs are being implemented properly. We recommend that construction of these basins be supervised by a qualified engineer familiar with state and local storm-water requirements.

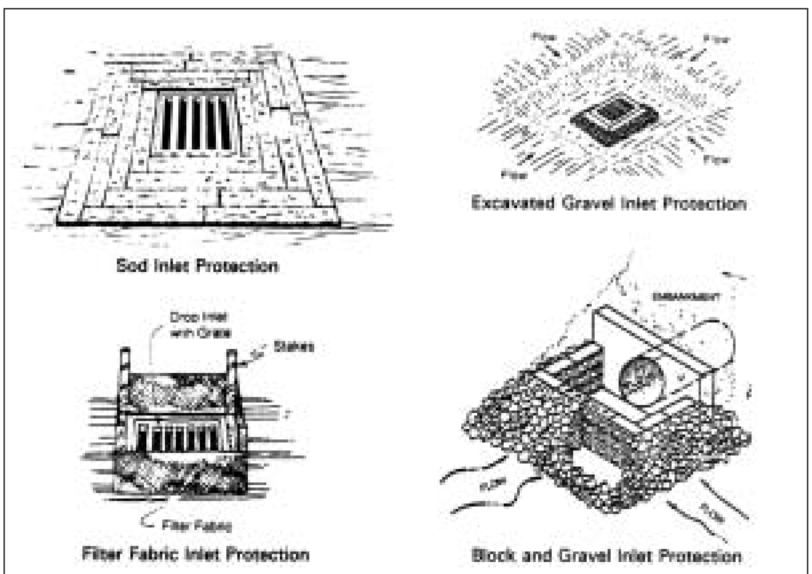
What are some advantages of sedimentation basins?

They protect downstream areas against clogging or damage and contain smaller sediment particles than sediment traps can due to their longer retention time.

What are some disadvantages?

Sedimentation basins are generally not suitable for large areas, require regular maintenance and cleaning, and will not remove very fine silts and clays unless used with other measures.

Figure 5. Storm Drain Inlet Protection



From U.S. EPA, 1992e.

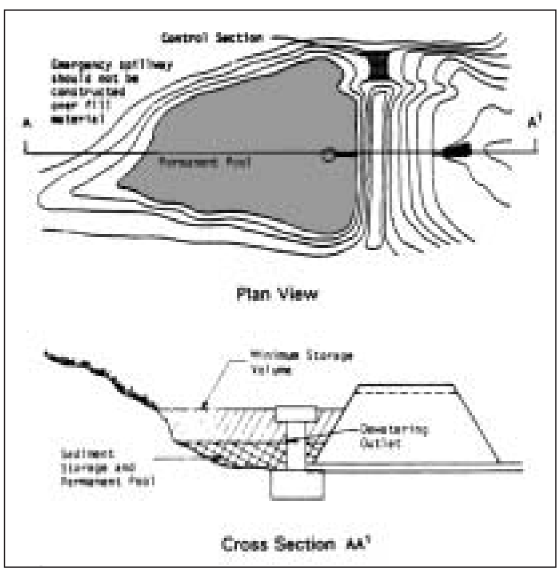
Check Dams

Small rock or log dams erected across a ditch, swale, or channel can reduce the speed of water flow in the conveyance. This reduces erosion and also allows sediment to settle out along the channel. Check dams are especially useful in steep, fast-flowing swales where vegetation cannot be established. For best results, it is recommended that you place check dams along the swale so that the crest of each check dam is at the same elevation as the toe (lowest point) of the previous (upstream) check dam. Check dams work best in conveyances draining small areas and should be installed only in man-made conveyances. Placement of check dams in streams is not recommended and might require a permit.

Terraces and Benches

Terraces and benches are earthen embankments with flat tops or ridge-and-channels. Terraces and benches hold moisture and minimize sediment loading in runoff. They can be used on land with no vegetation or where it is anticipated that erosion will be a problem. Terraces and benches reduce erosion damage by capturing storm-water runoff and directing it to an area where the runoff will not cause erosion or damage. For best results, this area should be a grassy waterway, vegetated area, or tiled outlet. Terraces and benches might not be appropriate for use on sandy or rocky slopes.

Figure 6.
Collection and Sedimentation Basin



From U.S. EPA, 1992e.

Outlet Protection

Stone, riprap, pavement, or other stabilized surfaces placed at a storm-water conveyance outlet are known as outlet protection (see Figure 7). Outlet protection reduces the speed of concentrated storm-water flows exiting the outlet, lessening erosion and scouring of channels downstream. It also removes sediment by acting as a filter medium. It is recommended that you consider installing outlet protection wherever predicted outflow velocities might cause erosion.

d. Infiltration

Infiltration measures such as vegetated filter strips, grassed swales, and infiltration trenches encourage quick infiltration of storm water into the ground rather than allowing it to remain as overland flow. Infiltration not only reduces runoff velocity, but can also provide some treatment of runoff, preserve natural stream flow, and recharge ground water. Infiltration measures can be inappropriate on unstable slopes or in cases where runoff might be contaminated,

What are some advantages of terraces and benches?

Terraces and benches reduce runoff speed and increase the distance of overland runoff flow. In addition, they hold moisture better than do smooth slopes and minimize sediment loading in runoff.

What are some disadvantages of terraces and benches?

Terraces and benches can significantly increase cut and fill costs and cause sloughing if excess water infiltrates the soil. They are not practical for sandy, steep, or shallow soils.

or where wells, foundations, or septic fields are nearby.

Vegetated Filter Strips and Grassed Swales

Vegetated filter strips are gently sloped areas of natural or planted vegetation. They allow water to pass over them in sheetflow (runoff that flows in a thin, even layer), infiltrate the soil, and drop sediment. Vegetated filter strips are appropriate where soils are well draining and the ground-water table is deep below the surface. They will not work effectively on slopes of 15 percent or more due to high runoff velocity. Strips should be at least 20 feet wide and 50 to 75 feet long in general, and longer on steeper slopes. If possible, it is best to leave existing natural vegetation in place as filter strips, rather than planting new vegetation, which will not function to capture eroded particles until it becomes established.

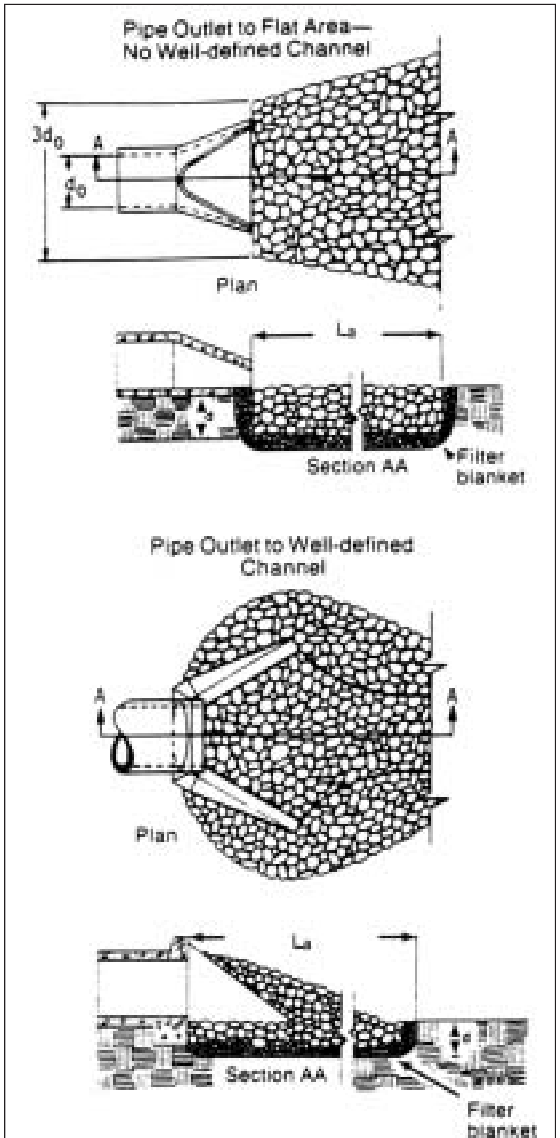
Grassed swales function similarly to non-vegetated swales (discussed earlier in this chapter) except that grass planted along the swale bottom and sides will slow water flow and filter out sediment. Permeable soil in which the swale is cut encourages reduction of water volume through infiltration. Check dams (discussed earlier in this chapter) are sometimes provided in grassed swales to further slow runoff velocity, increasing the rate of infiltration.

To optimize swale performance, it is best to use a soil which is permeable but not excessively so; very sandy soils will not hold vegetation well and will not form a stable channel structure. It is also recommended that you grade the swale to a very gentle slope to maximize infiltration.

Infiltration Trenches

An infiltration trench (see Figure 8) is a long, narrow excavation ranging from 3 to 12 feet deep. It is filled with stone to allow for temporary storage of storm water in the open spaces between the stones. The water eventually infiltrates the surrounding soil or is collected by perforated pipes in the bottom of the trench and conveyed to an outflow point. Such trenches can remove fine sediments and

Figure 7. Outlet Protection



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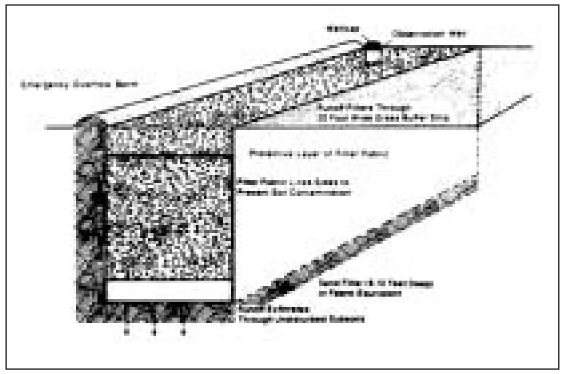
soluble pollutants. They should not be built in relatively impervious soils, such as clay, that would prevent water from draining from the bottom of the trench; less than 3 feet above the water table; in soil that is subject to deep frost penetration; or at the foot of slopes steeper than 5 percent. Infiltration trenches should not be used to handle contaminated runoff. Runoff can be pretreated using a grass buffer/filter strip or treated in the trench with filter fabric.

Figure 8. Infiltration Trench



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e. *Other Practices*

Additional practices exist that can help prevent contamination of surface water such as preventive monitoring, dust control, vehicle washing, and discharge to wetlands. Many of these practices are simple and inexpensive to implement while others, such as monitoring, can require more resources.

Preventive Monitoring

Preventive monitoring includes automatic and control systems, monitoring of operations by waste management unit personnel, and testing of equipment. These processes can help to ensure that equipment functions as designed and is in good repair so that spills and leaks, which could contaminate adjacent surface waters, are minimized and do not go undetected when they do occur. Some automatic monitoring equipment, such as pressure gauges coupled with pressure relief devices, can correct problems without human intervention, preventing leaks or spills that could contaminate surface water if allowed to occur. Other monitoring equipment can provide early warning of problems so that personnel can intervene before leaks or spills occur. Systems that could contaminate surface water if they failed and that could benefit from automatic monitoring or early warning devices include leachate pumping and treatment systems, liquid waste distribution and storage systems at land application units, and contaminated runoff conveyances.

Dust Control

In addition to being an airborne pollutant, dust can settle in areas where it can be picked up by runoff or can be transported by air and deposited directly into surface waters. Dust particles can carry pollutants and can also result in sedimentation of waterbodies. Several methods of dust control are available to prevent this. These include irrigation, chemical treatments, minimization of exposed soil areas, wind breaks, tillage, and sweeping. For further information on dust control, consult Chapter 8–Operating the Waste Management System.

Vehicle Washing

Materials that accumulate on tires and other vehicle surfaces and then disperse across a facility are an important source of surface-water contamination. Vehicle washing removes materials such as dust and waste. Washing stations can be located near waste transfer areas or near the waste management site exit. Pressurized water spray is usually sufficient to remove dust. Waste water from vehicle washing operations should be contained and handled appropriately. Discharge of such waste water requires an NPDES permit other than the Multi-Sector General Permit.

Discharges to Wetlands

Discharge to constructed wetlands is a method less frequently used and can involve complicated designs. The discharge of storm water into natural wetlands, or the modification of wetlands to improve their treatment capacity, can damage a wetland ecosystem and, therefore, is subject to federal, state, and local regulations.

Constructed wetlands provide an alternative to natural wetlands. A specially designed pond or basin, which is lined in some cases, is stocked with wetland plants that can control sedimentation and manage pollutants through biological uptake, microbial action, and other mechanisms. Together, these processes often result in better pollutant removal than would be expected from sedimentation alone. When designing constructed wetlands, you should consider 1) that maintenance might include dredging, similar to that required for sedimentation basins, 2) provisions for a dry-weather flow to maintain the wetlands, 3) measures to limit mosquito breeding, 4) structures to prevent escape of floating wetland plants (such as water hyacinths) into downstream areas where they are undesirable, and 5) a program of harvesting and replacing plants.

What are some advantages of constructed wetlands?

Provide aesthetic as well as water quality benefits and areas for wildlife habitat.

What are some disadvantages of constructed wetlands?

Discharges to wetlands might be subject to multiple federal, state, and local regulations. In addition, constructed wetlands might not be feasible if land is not available and might not be effective as a storm-water control measure until time has been allowed for substantial plant growth.

B. Controls to Address Surface-water Contamination from Ground Water to Surface Water

Generally, the use of liners and groundwater monitoring systems will reduce potential contamination from ground water to surface water. For more information on protecting ground water, refer to Chapter 7: Sections A–Assessing Risk, Section B–Designing and Installing Liners, and Section C–Designing a Land Application Program.

C. Controls to Address Surface-water Contamination from Air to Surface Water

Emission control techniques for volatile organic compounds (VOC) and particulates can assist in reducing potential contamination of surface water from air. Refer to Chapter 5–Protecting Air Quality, for more information on air emission control techniques.

V. Methods of Calculating Run-on and Runoff Rates

The design and operation of surface-water protection systems will be driven by anticipated storm-water flow. Run-on and runoff flow rates for the chosen design storm event should be calculated in order to: 1) choose the proper type of storm-water controls to install, and 2) properly design the controls and size the chosen control measures to minimize impacts to surface water. Controls based on too small a design storm event, or sized without calculating flows will not function properly and can result in releases of contaminated storm water. Similarly, systems can also be designed for too large a flow, resulting in unnecessary control and excessive costs.

The usual approach for sizing surface-water protection systems relies on the use of standardized "design storms." A design storm is, in theory, representative of many recorded storms and reflects the intensity, volume, and duration of a storm predicted to occur once in a given number of years. In general, surface-water protection structures should be designed to handle the discharge from a 24-hour, 25-year storm event (i.e., a rainfall event of 24 hours duration and of such a magnitude that it has a 4 percent statistical likelihood of occurring in any given year). Figure 9 presents a typical intensity-duration-frequency curve for rainfall events.

The Hydrometeorological Design Studies Center (HDSC) at the National Weather Service has prepared *Technical Paper 40, Rainfall Frequency Atlas of the United States for Durations From 30 Minutes to 24 Hours and Return Periods From 1 to 100 Years* (published

Rational Method for Calculating Storm-Water Runoff Flow

$Q = cia$

where,

Q = peak flow rate (runoff), expressed in cubic feet per second (cfs)*

c = runoff coefficient, unitless. The coefficient c is not directly calculable, so average values based on experience are used. Values of c range from 0 (all infiltration, no runoff) to 1 (all runoff, no infiltration). For example, flat lawns with sandy soil have a c value of 0.05 to 0.10, while concrete streets have a c value of 0.80 to 0.95.

i = average rainfall intensity, expressed in inches per hour, for the time of concentration, tc, which is a calculable flow time from the most distant point in the drainage area to the point at which Q is being calculated. Once tc is calculated and a design storm event frequency is selected, i can be obtained from rainfall intensity-duration-frequency graphs (see Figure 9).

a = drainage area, expressed in acres. The drainage area is the expanse in which all runoff flows to the point at which Q is being calculated.

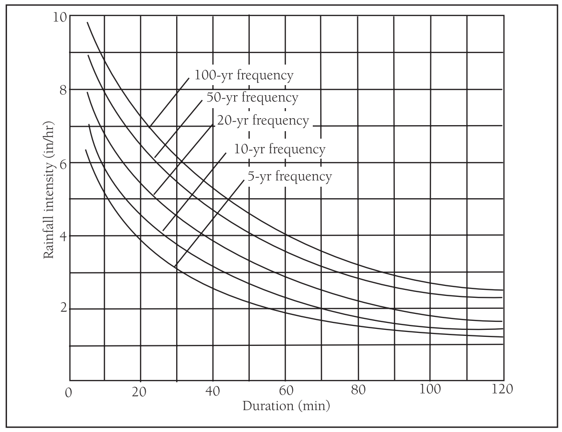
* Examining the units of i and a would indicate that Q should be in units of ac-in/hr. However, since 1 ac-in/hr = 1.008 cfs, the units are interchangeable with a negligible loss of accuracy. Units of cfs are usually desired for subsequent calculations.

in 1961). This document contains rainfall intensity information for the entire United States. Another HDSC document, *NOAA Atlas 2, Precipitation Frequency Atlas of the Western United States* (published in 1973) comes in 11 volumes, one for each of the 11 westernmost of the contiguous 48 states. Precipitation frequency maps for the eleven western most states are available on the Western Regional Climate Center's Web page at **<www.wrcc.sage.dri.edu/ pcpnfreq.html>**. HDSC is currently assembling more recent data for some areas. Your state or local regulatory agency might be able to provide data for your area.

Several methods are available to help you calculate storm-water flows. The Rational Method can be used for calculating runoff for areas of less than 200 acres. Another useful tool for estimating storm-water flows is the Natural Resource Conservation Service's TR-55 software.[5] TR-55 estimates runoff volume from accumulated rainfall and then applies the runoff volume to a simplified hydrograph for peak discharge total runoff estimations.

Computer models are also available to aid in the design of storm-water control systems. For example, EPA's Storm Water Management Model (SWMM) is a comprehensive model capable of simulating the movement of precipitation and pollutants from the ground surface through pipe and channel networks, storage treatment units, and finally to receiving water bodies. Using SWMM, it might be possible to perform both single-event and continuous simulation on catchments having storm sewers and natural drainage, for prediction of flows, stages, and pollutant concentrations.

Figure 9. Typical Intensity-Duration-Frequency Curves



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Some models, including SWMM, were developed for purposes of urban storm-water control system design, so it is important to ensure that their methodology is applicable to the design of industrial waste management units. As with all computer models, these should be used as part of the array of design tools, rather than as a substitute for careful consideration of the unit's design by qualified professionals.

[5] TR-55, Urban Hydrology for Small Watersheds Technical Release 55, presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. This software is suited for use in small and especially urbanizing watersheds. TR-55 can be downloaded from the National Resource Conservation Service at **<www.wcc.nrcs.usda.gov/water/quality/common/tr55/tr55.html>**.

Storm Water Management Model (SWMM). Simulates the movement of precipitation and pollutants from the ground surface through pipe and channel networks, storage treatment units, and receiving waters.

BASINS: A Powerful Tool for Managing Watersheds. A multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools into one package.

Source Loading and Management Model (SLAMM). Explores relationships between sources of urban runoff pollutants and runoff quality. It includes a wide variety of source area and outfall control practices. SLAMM is strongly based on actual field observations, with minimal reliance on theoretical processes that have not been adequately documented or confirmed in the field. SLAMM is mostly used as a planning tool, to better understand sources of urban runoff pollutants and their control.

Simulation for Water Resources in Rural Basins (SWRRB). Simulates hydrologic, sedimentation, and nutrient and pesticide transport in large, complex rural watersheds. It can predict the effect of management decisions on water, sediment, and pesticide yield with seasonable accuracy for ungauged rural basins throughout the United States.

Pollutant Routing Model (P-ROUTE). Estimates aqueous pollutant concentrations on a stream reach by stream reach flow basis, using 7Q10 or mean flow.

Enhanced Stream Water Quality Model (QUAL2E). Simulates the major reactions of nutrient cycles, algal production, benthic and carbonaceous demand, atmospheric reaeration and their effects on the dissolved oxygen balance. It is intended as a water quality planning tool for developing total maximum daily loads (TMDLs) and can also be used in conjunction with field sampling for identifying the magnitude and quality characteristics of nonpoint sources.

Protecting Surface Water Activity List

You should conduct the following activities when designing or operating surface-water protection measures or systems in conjunction with waste management units.

- ❑ Comply with applicable National Pollutant Discharge Elimination System (NPDES), state, and local permitting requirements.
- ❑ Assess operating practices, identify potential pollutant sources, determine what constituents in the unit pose the greatest threats to surface water, and calculate storm-water runoff flows to determine the need for and type of storm-water controls.
- ❑ Choose a design storm event (e.g., a 24-hour, 25-year event) and obtain precipitation intensity data for that event to determine the most appropriate storm-water control devices.
- ❑ Select and implement baseline and activity-specific BMPs, such as good housekeeping practices and spill prevention and response plans as appropriate for your waste management unit.
- ❑ Select and establish site-specific BMPs, such as diversion dikes, collection and sedimentation basins, and infiltration trenches as appropriate for your waste management unit.
- ❑ Develop a plan for inspecting and maintaining the chosen storm-water controls; if possible, include these measures as part of the operating plan for the waste management unit.

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